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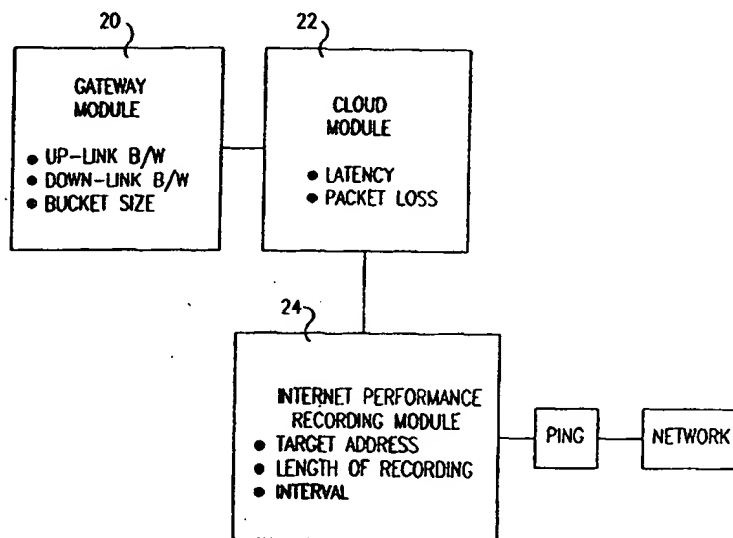
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(54) Title: APPARATUS AND METHOD FOR TESTING NETWORK APPLICATIONS



## (57) Abstract

A system for modeling a network consists of 3 principal modules, a gateway module (20), a cloud module (22), and an Internet performance recording module (24). The system includes a sending device, a receiving device, a measuring device, a counter, a network parameter reconstructor, and a modeling device. The system is associated with a location on the network. The sending device sends data units from the system location to a second, predefined location on the network and arranges for the units to return to the system location. The receiving device receives the units on their return to the system location. The measuring device measures the delay between the sending of the unit and the receipt of the same unit by return. The counter counts the number of units that do not return. The network parameter reconstructor reconstructs parameters of the network.

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## APPARATUS AND METHOD FOR TESTING NETWORK APPLICATIONS

### FIELD OF THE INVENTION

The present invention relates to an apparatus and method for testing  
5 network applications, and more particularly but not exclusively to testing  
applications for use with wide area networks (WANS) and with the Internet.

### BACKGROUND OF THE INVENTION

10 In recent years there has been considerable growth, in use of WANs and  
the Internet. This growth has been both in terms of the number of people and  
organizations using such facilities and also in terms of the network capacity taken  
up by the various applications. The past few years have also noted the  
appearance and spread of applications such as the Internet phone which require  
15 the reliable transfer of data in real time.

All three of these developments have led to vast increases in the quantity  
of data on the Internet, and all regular users are aware that there are times of the  
day when Internet traffic is very slow and real time applications become all but  
impossible to use.

20 An organization setting up a connection between different sites will wish  
to be certain that the connection will be able to support its applications at all times  
of operation. This applies whether the organization intends to use the Internet for  
its connection or whether it is designing its own WAN and wishes to decide on the  
necessary design capacity.

At present there is known a system for testing the capacity of a network to support an application. It is possible to model a network using three parameters, a maximum bandwidth, a time delay and a percentage loss of data packets. The system uses a fixed set of parameters obtained from general experience of the Internet and the parameters can be changed by the user if he feels that the system does not accurately represent the connection being tested.

A problem with this system is that the parameters of a real network change with time, sometimes quite rapidly. An application that passes the test using the above system may fail in actual use on the network because, for a small percentage of the time, the connection between two specific points on the network varies markedly from an expected value. Alternatively the very fact that values are changing may affect performance.

In response to the latter point it is known, not to provide the system with specific parameters but rather with a time-variant set of parameters. This, however, still does not deal with the problem of radical and unexpected changes and furthermore does not deal adequately with the behavior patterns of specific networks or of specific routes on a given network. In particular it does not deal adequately with attempts to set up a connection between two points via the Internet.

## SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a system for modeling a network. The system is associated with a location on the network and comprises a sending device for sending data units from the system  
5 location to a second, predefined location on the network and arranging the units to return to the system location, a receiving device for receiving the units on their return to the system location, a measuring device for measuring the delay between the sending of the unit and the receipt of the same unit by return, and a counter for counting the number of units that do not return, a network parameter  
10 reconstructor for reconstructing, from the measuring device and from the counter, parameters of the network, and a modeling device adapted to utilize the reconstructed parameters to model the network. The sending device is preferably operative to send data units at predefined intervals over a preset period.

An array may be built up of delays of succeeding units and may provide  
15 parameters for the modeling of the network. A particular advantage of the invention is that it is able to model the Internet effectively, however it is applicable to any other type of communication network as well. The invention is useful in determining the performance of a network application having predefined functions. The application would be combined with the system as described  
20 above and one or more of the predefined functions of the application would be carried out in the normal way, as if the application were connected to the network. As the system is built in behind the network driver the application believes it is operating normally with the network but, instead of the packets being output to a genuine network they are output to the model and dealt with according to the

retrieved parameters. Thus the user receives an indication as to actual performance of the system on the network based on the time delays and loss rates in the delivery of packets and is able to see from this whether the use of the particular application over the given network is feasible or not.

5           According to a second aspect of the present application there is provided a system for modeling a network, the system being associated with a first location on said network and comprising a network performance reporting module for obtaining parameters from a network and a cloud module for incorporating the parameters obtained from the network performance reporting module to form a  
10   model of the network, the network performance reporting module being characterized in that it comprises a sending device for sending data units from the first location to a second, predefined location on the network and arranging the units to return to the first location, a receiving, device for receiving the units on their return to the first location, a measuring device for measuring, the delay  
15   between the sending of the unit and the receipt of the same unit by return, a counter for counting the number of units that do not return, and a modeling device adapted to model a network in accordance with the measured delay of the measuring device and the count of the counter.

          The units may be data packets in a standard format and the sending  
20   device may be operative to send data units at predefined intervals over a preset period. The array may be built up of delays of succeeding units and may be usable to provide parameters for the modeling of the network.

The system may be embodied on a computer. The system may also be embodied on several computers. For example the modeling device may be embodied on a separate computer from the rest of the system.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, purely by way of example, to the accompanying drawings in which,

5           Figure 1 shows a part of a network such as the Internet,

Figure 2A shows a path that a communication may take through a series of routers,

Figure 2B shows how the path of figure 2A is considered in a cloud model,

10           Figure 3 shows a typical distribution of delay times for data packets following a path across a network,

Figure 4 shows a model according to an embodiment of the present invention,

Figure 5A shows a standard network application, and

15           Figure 5B shows how an embodiment of the present invention may be added to the application of figure 5A.



## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a part of a network. A series of endpoints 10.1 – 10.3, which represent individual users, or in the case of the Internet, Internet service providers, are connected to a network via gateways 12.1 – 12.3. Linking the gateways are individual routers 14.1 – 14.8 whose task it is to read the addresses of data packets and to direct the packet to the most appropriate of the neighboring routers for the given destination. For example Router 2, when faced with a message for endpoint 10.2, should know that it must direct the message to Router 3 and not to Router 4. If it does send it via Router 4 then Router 4 should send it via Router 6 and Router 9, and Router 9 should know to direct it via Router 8 to ensure that it reaches the correct endpoint.

Figure 2A shows a path that an actual message may take through a series of routers. Each router takes two parameters, one is the percentage of packets lost over this part of the network and the second is the delay time introduced over this part of the network. The routers are treated as nodes of the network. The parameters of each node will change rapidly, especially during periods of heavy use of the network and it is not feasible to keep track of the parameters of every single node.

Figure 2B shows how the network may be modeled. It is modeled as a cloud which has parameters which are the sum of the individual parameters of the routers. The parameters of the cloud are more stable than the parameters of individual routers for messages being sent over any appreciable number of routers because statistical effects begin to appear. Thus it is feasible, as has been done in the prior art, to use a model of this sort, with sets of predetermined

parameters, to model the behavior of the network. This works well up to a point, but as mentioned above, cannot deal effectively with data intensive communications needing to work in real time because standard sets of parameters do not really deal with the effects of short term but exceptionally large scale fluctuations at individual routers. For that matter standard sets of parameters do not deal with specific conditions applying to the individual route that the user is interested in.

There is currently known a utility called "ping", based on the ICMP protocol, which is used to check the viability of Internet connections. The "ping" or another like utility, sends a data packet to the desired address. The data packet is immediately returned from the desired address to the sender and the sender is thus able to know that the connection is viable and is able to determine the time delay over the connection.

Embodiments of the present invention use a variation of the "ping" utility to determine the actual time-variant parameters of the network for use in the model of figure 2B. A series of "pings" are transmitted over the connection under test at regular intervals, for example every half second, and the returning data packets are used to build up a graph of delay times. A data loss parameter is calculated from the number of packets that do not return. It will be appreciated that the actual parameters used in the model are half the values obtained because the packets traverse the network twice. However the fact that each packet traverses the network twice gives additional statistical soundness to the results.

A typical graph of delay times that might be obtained using the above described means is shown in figure 3.

The graph that is drawn up can then be used to provide time varying parameters for the model of figure 2B, and the model of figure 2B can be used to  
5 test applications under the expected conditions of actual use.

Figure 4 shows how the model of figure 2B may be implemented and how it may obtain and use parameters obtained from the network.

The model shown in figure 4 consists of three principal modules, a gateway module 20, a cloud module 22 and an Internet performance recording  
10 module 24. The gateway module models the gateway to the Internet and takes the following parameters, up-link bandwidth, down-link bandwidth and bucket (or buffer) size. The bucket size is the maximum buffer size offered by the connection and presents a challenge, particularly to real time applications. The maximum number of data packets that can be sent to the network is limited by the  
15 up-link bandwidth. The remainder must be queued in the buffer. Data packets that arrive when the buffer is full are simply lost.

The cloud module 22 is the model of figure 2B, and takes as its parameters the latency, that is the delay in delivery of packets over the connection, and packet loss, as discussed above.

20 Module 24 is the Internet performance recording module and its task is to obtain the data for the graph of figure 3. It takes parameters from the user as follows, a target address, the length of time for which parameters are needed, and the sampling interval. It then proceeds to operate a "ping" utility repeatedly at the set rate over the set time interval. The parameters are recorded, in a form

functionally equivalent to figure 3, and the results are used as the parameters for the cloud module 22.

In embodiments of the invention there are two ways that the cloud module selects parameters from the graph of figure 3. The first method is to proceed sequentially through the graph. The second method is to select parameters by making random jumps through the graph. The second method models a network with particularly high jitter, that is to say with sharp changes in the delay and such a test is particularly important for real time data which is very vulnerable to such behavior from a network.

Cloud software includes two components, an application and a driver. The driver is where execution of the simulation is carried out. A typical networking architecture may allow for three basic types of driver, adapters, protocols and intermediate drivers. In a standard system, as shown in figure 5A, a TCP/IP driver 30, used for communication via the Internet, is shown bound to an adapter driver 32. Figure 5B shows an Internet communication of the type shown in figure 5A which has been adapted for the purposes of the present invention. In figure 5B the modeling software of the invention is installed as an intermediate cloud driver 34 which is located between the TCP/IP driver 30 and the adapter driver 32. The adapter driver 32 and the TCP/IP driver are both unaware of the existence of the cloud driver 34 and in this way it is ensured that the protocol behavior does not change.

There is thus achieved a means of accurately modeling a network connection, including an Internet connection, using parameters taken from the

network itself. The behavior of the module can be controlled by the user and the model is applicable to a wide variety of networks.

It is appreciated that various features of the invention which are, for clarity, described in the contexts of separate embodiments may also be provided  
5 in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment may also be provided separately or in any suitable subcombination.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described  
10 hereinabove. Rather, the scope of the present invention is defined only by the claims that follow:

**CLAIMS**

1. A system for modeling a network, the system being associated with a location on the network, the system comprising:

a sending device for sending data units from the system location to  
5 a second, predefined location on the network and arranging the units to return to the system location;

a receiving device for receiving the units on their return to the system location;

a measuring device for measuring the delay between the sending  
10 of the unit and the receipt of the same unit by return;

a counter for counting the number of units that do not return;

a network parameter reconstructor for reconstructing, from the measuring device and from the counter, parameters of the network; and

a modeling device adapted to utilize the reconstructed parameters  
15 to model the network.

2. A system for modeling a network, the system being associated with a first location on said network and comprising a network performance reporting module for obtaining parameters from a network and a cloud module for incorporating the parameters obtained from the network  
20 performance reporting module to form a model of the network, the network performance reporting module being characterized in that it comprises:

a sending device for sending data units from the first location to a second, predefined location on the network and arranging the units to return to the first location;

5 a receiving device for receiving the units on their return to the first location;

a measuring device for measuring the delay between the sending of the unit and the receipt of the same unit by return;

a counter for counting the number of units that do not return; and

10 a modeling device adapted to model a network in accordance with the measured delay of the measuring device and the count of the counter.

3. A system according to any preceding claim wherein the sending device is operative to send data units at predefined intervals over a preset period.
- 15 4. A system according to claim 3 wherein an array is built up of delays of succeeding units.
5. A system according to claim 4 wherein the array is usable to provide parameters for the modeling of the network.
6. A system according to any preceding claim wherein the network is the  
20 Internet.
7. A system according to any preceding claim wherein the units are data packets in a standard format.

8. A system according to any preceding claim further comprising the parameters of a network gateway.
9. A system according to any preceding claim combined with a network application.
- 5 10. A system according to any preceding claim wherein at least one of the devices is embodied on a first computer and at least one other of the devices is embodied on a second computer.
11. A method of modeling a network by using a system according to any preceding claim.
- 10 12. A method of determining the performance of a network application having predefined functions comprising the steps of:
  - combining the application with the system of any preceding claim;
  - and
  - carrying out one or more of the predefined functions of the
- 15 application.



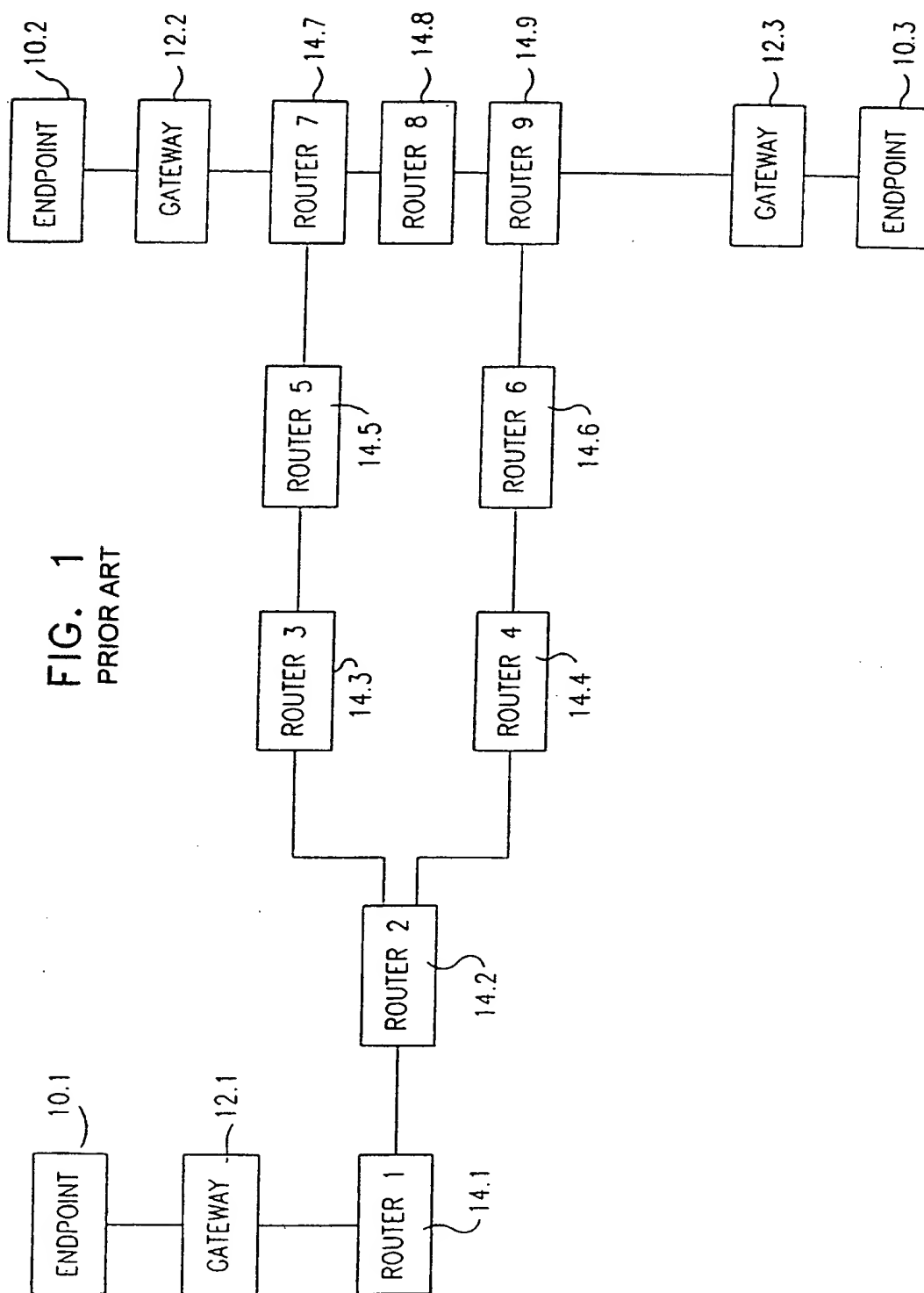


FIG. 2A  
PRIOR ART

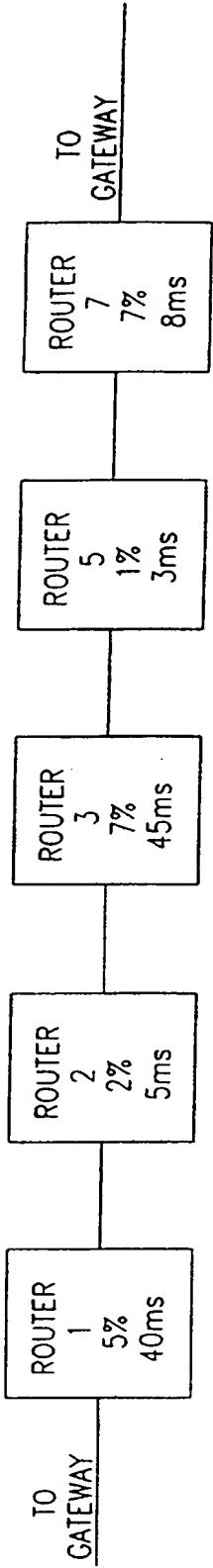


FIG. 2B  
PRIOR ART

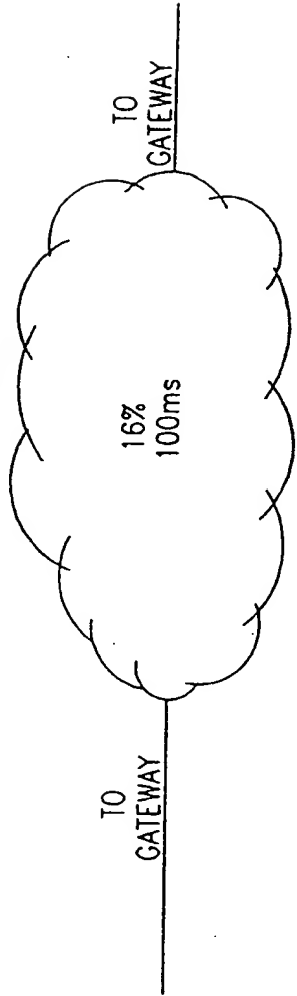
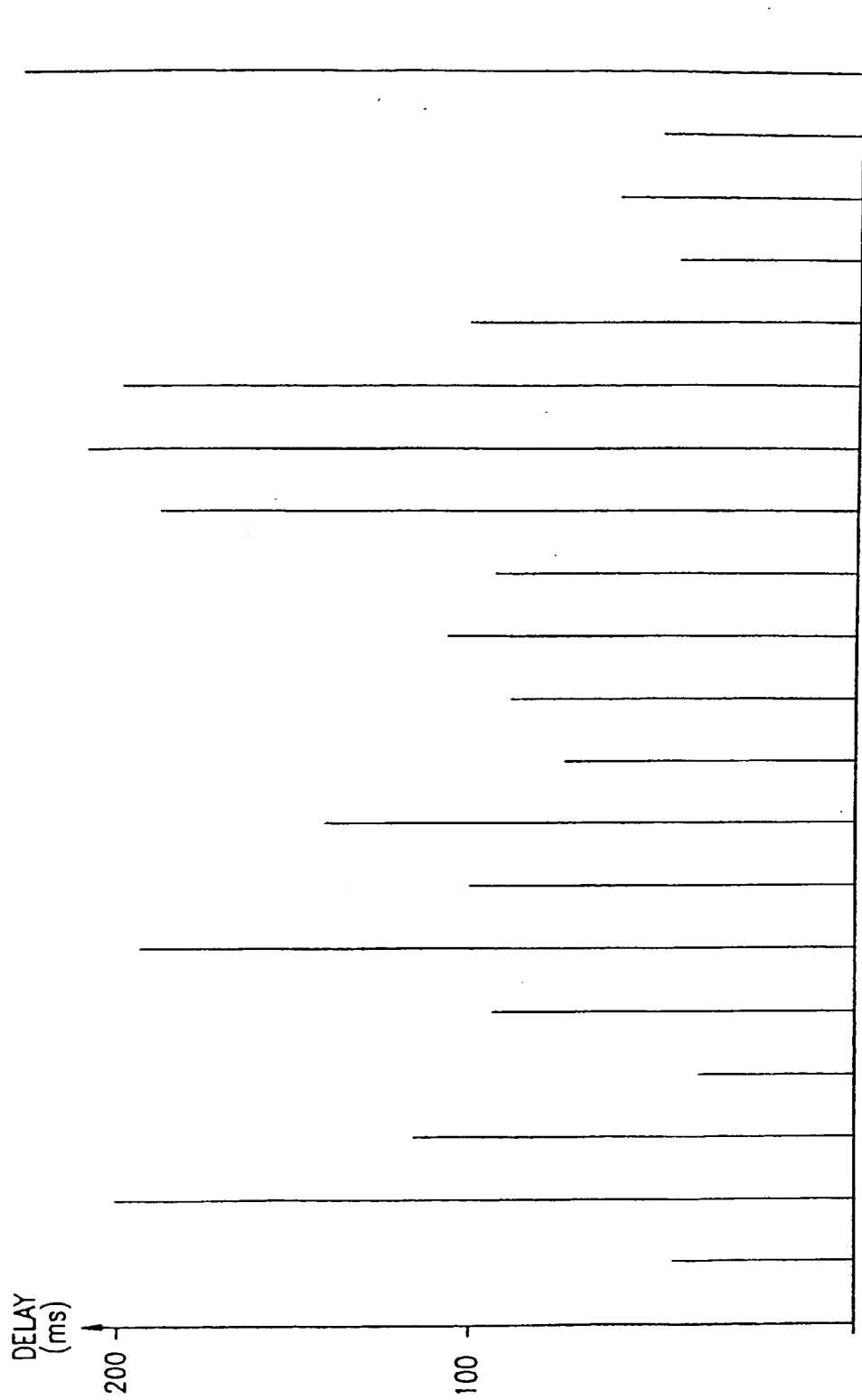


FIG. 3  
PRIOR ART



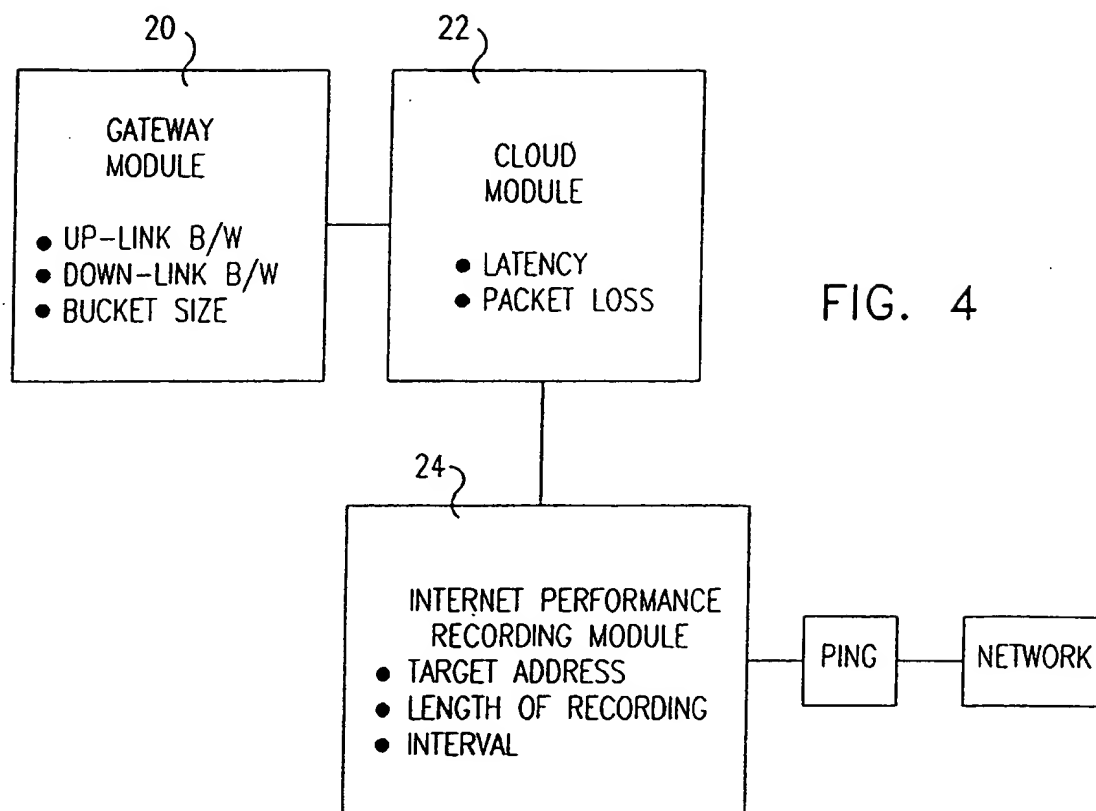


FIG. 5A  
PRIOR ART

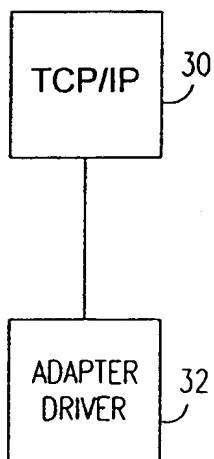
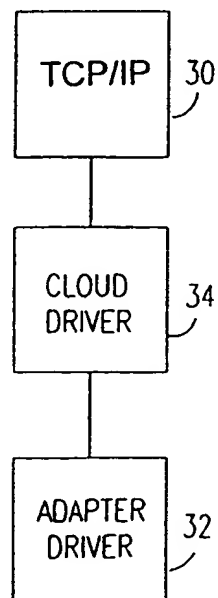


FIG. 5B



# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/IL99/00289

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G06F 11/00

US CL : 714/43, 4, 7

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 714/43, 4, 7

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,093,824 A [COAN et al] 03 March 1992, see entire document.	1-12
A	US 5,436,909 A [DEV et al] 25 July 1995, see entire document	1-12
A	US 5,493,650 A [REINKE et al] 20 February 1996, see entire document	1-12
A	US 5,528,594 A [BUTTER et al] 18 June 1996, see entire document	1-12
A	US 5,613,061 A [TAYLOR] 18 March 1997, see entire document	1-12
A	US 5,751,933 A [DEV et al] May 12 1998, see entire document	1-12



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

12 SEPTEMBER 1999

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# INTERNATIONAL SEARCH REPORT

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## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	US 5,870,540 A [WANG et al] 09 February 1999, see entire document	1-12